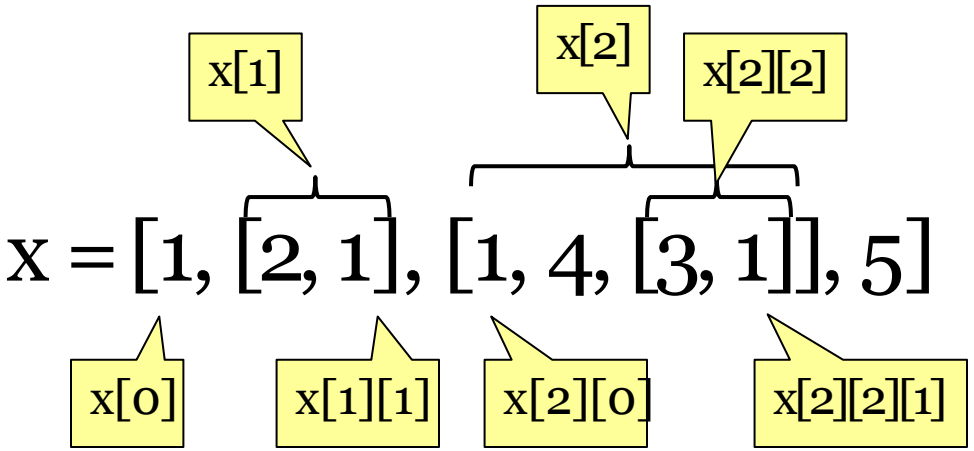
Lecture 14

Nested Lists and Dictionaries

Nested Lists

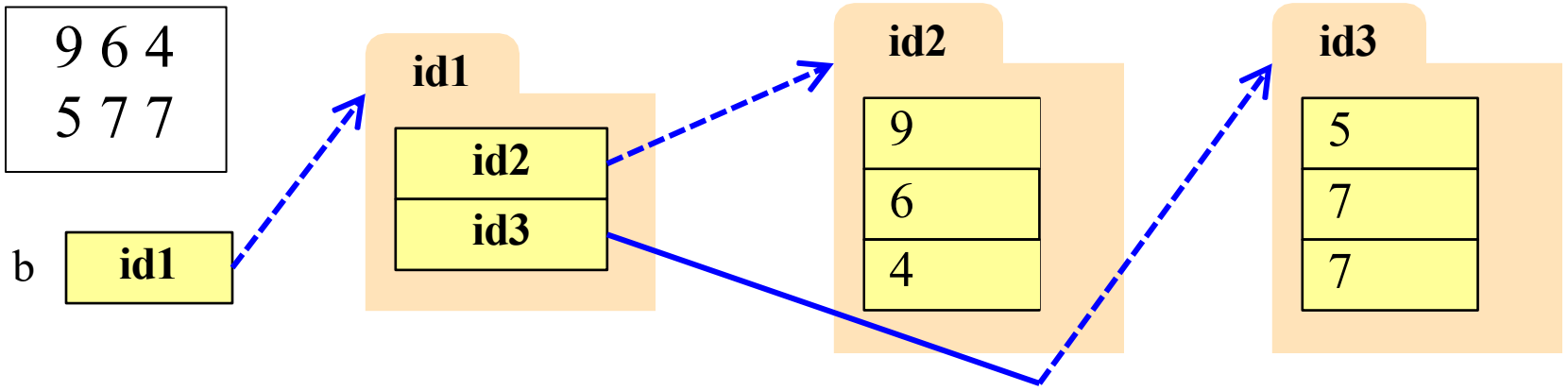
- Lists can hold any objects
- Lists are objects
- Therefore lists can hold other lists!

```
a = [2, 1]
b = [3, 1]
c = [1, 4, b]
x = [1, a, c, 5]
```



How Multidimensional Lists are Stored

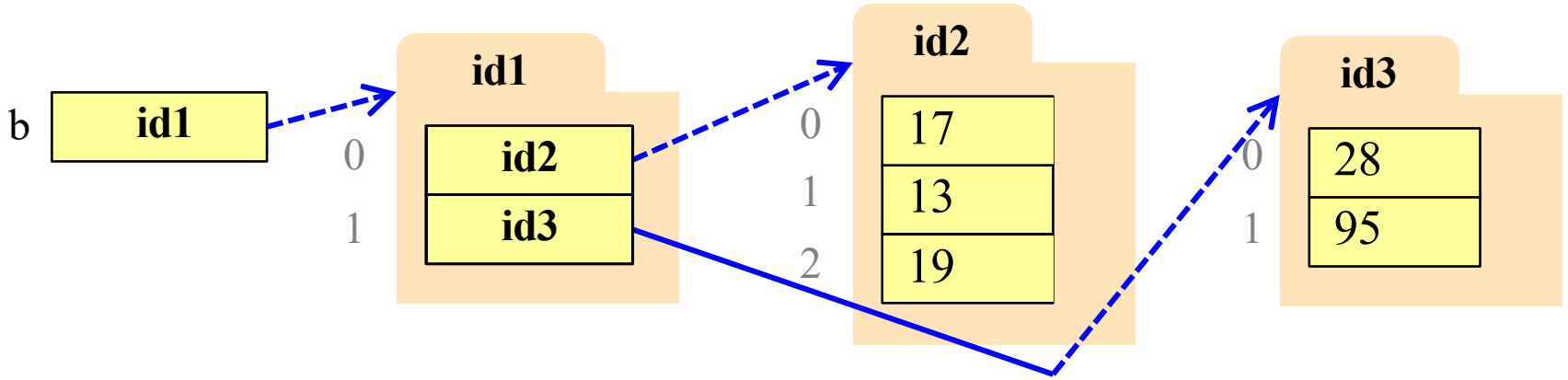
- b = [[9, 6, 4], [5, 7, 7]]



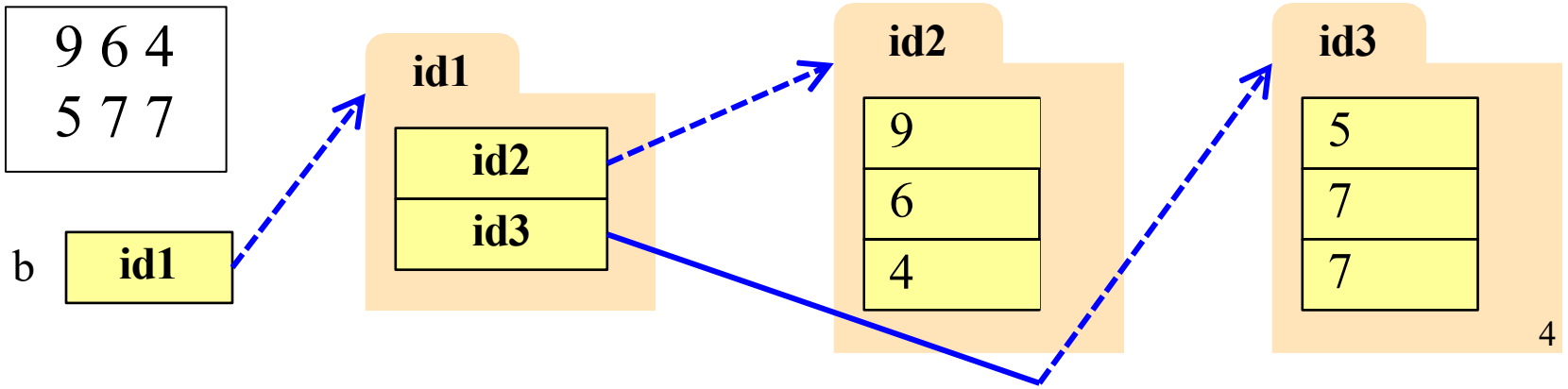
- b holds name of a two-dimensional list
  - Has len(b) elements
  - Its elements are (the names of) 1D lists
- b[i] holds the name of a one-dimensional list (of ints)
  - Has len(b[i]) elements

Ragged Lists vs Tables

- Ragged is 2d uneven list: b = [[17,13,19],[28,95]]



- Table is 2d uniform list: b = [[9,6,4],[5,7,7]]



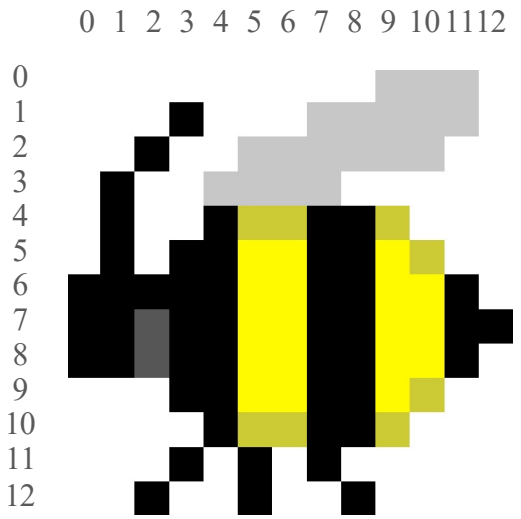
Nested Lists can Represent Tables

Spreadsheet

	0	1	2	3
0	5	4	7	3
1	4	8	9	7
2	5	1	2	3
3	4	1	2	9
4	6	7	8	0

table.csv

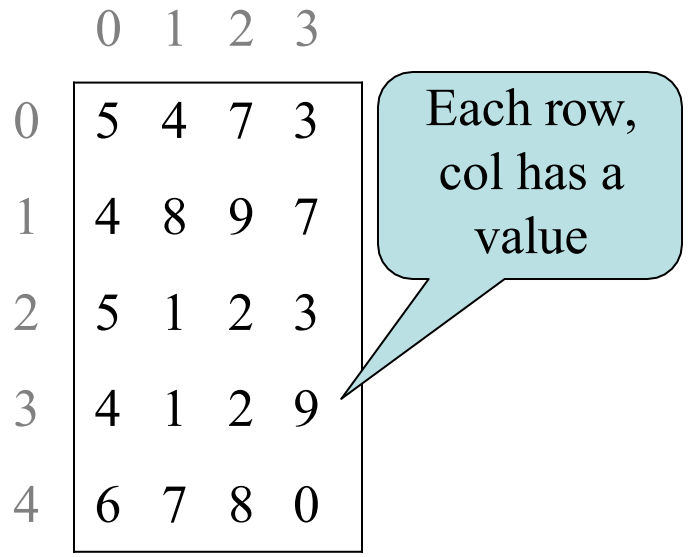
Image



smile.xlsx

Representing Tables as Lists

Spreadsheet



- Represent as 2d list
  - Each table row a list
  - List of all rows
  - **Row major order**
- Column major exists
  - Less common to see
  - Limited to some scientific applications

```
d = [[5,4,7,3],[4,8,9,7],[5,1,2,3],[4,1,2,9],[6,7,8,0]]
```

Overview of Two-Dimensional Lists

- Access value at row 3, col 2:

  d[3][2]

- Assign value at row 3, col 2:

  d[3][2] = 8

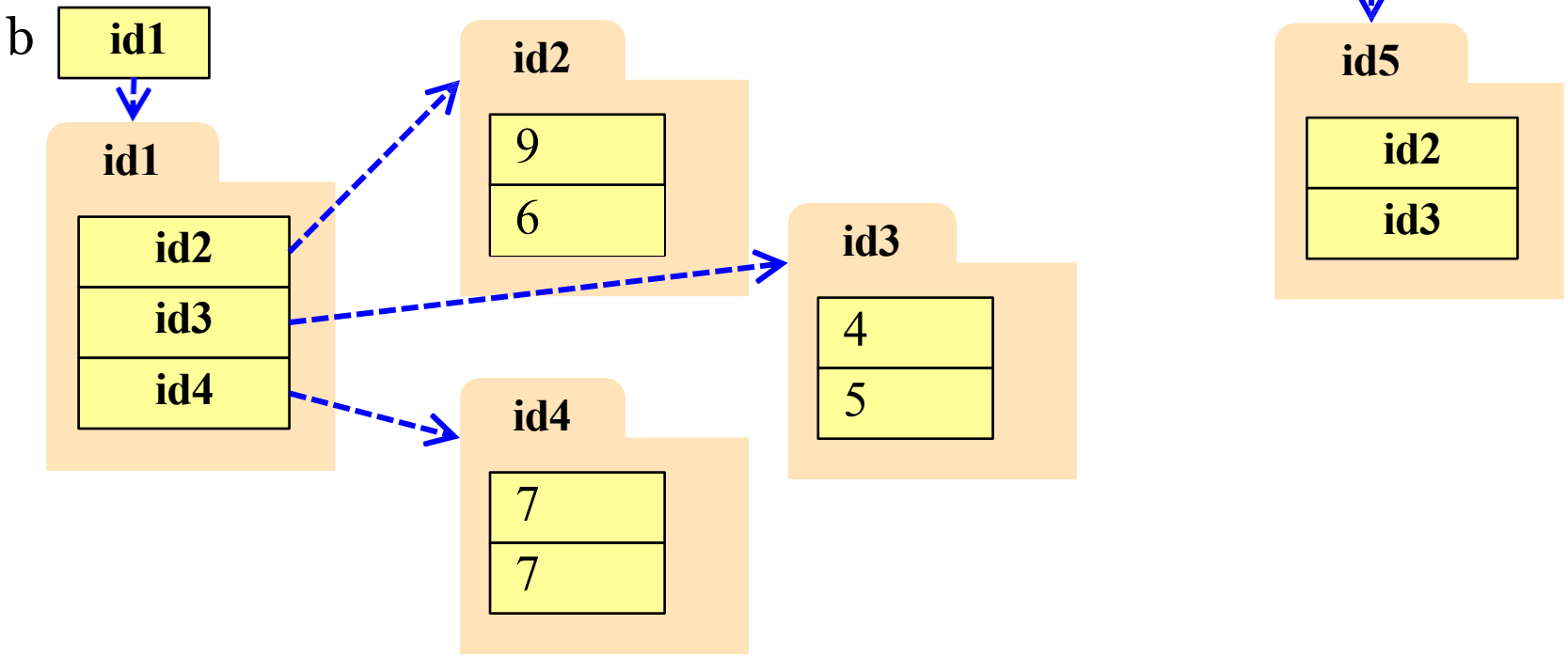
- **An odd symmetry**
  - Number of rows of d: len(d)
  - Number of cols in row r of d: len(d[r])

d	0	1	2	3
0	5	4	7	3
1	4	8	9	7
2	5	1	2	3
3	4	1	2	9
4	6	7	8	0

Slices and Multidimensional Lists

- Only "top-level" list is copied.
- Contents of the list are not altered
- b = [[9, 6], [4, 5], [7, 7]]

x = b[:2]



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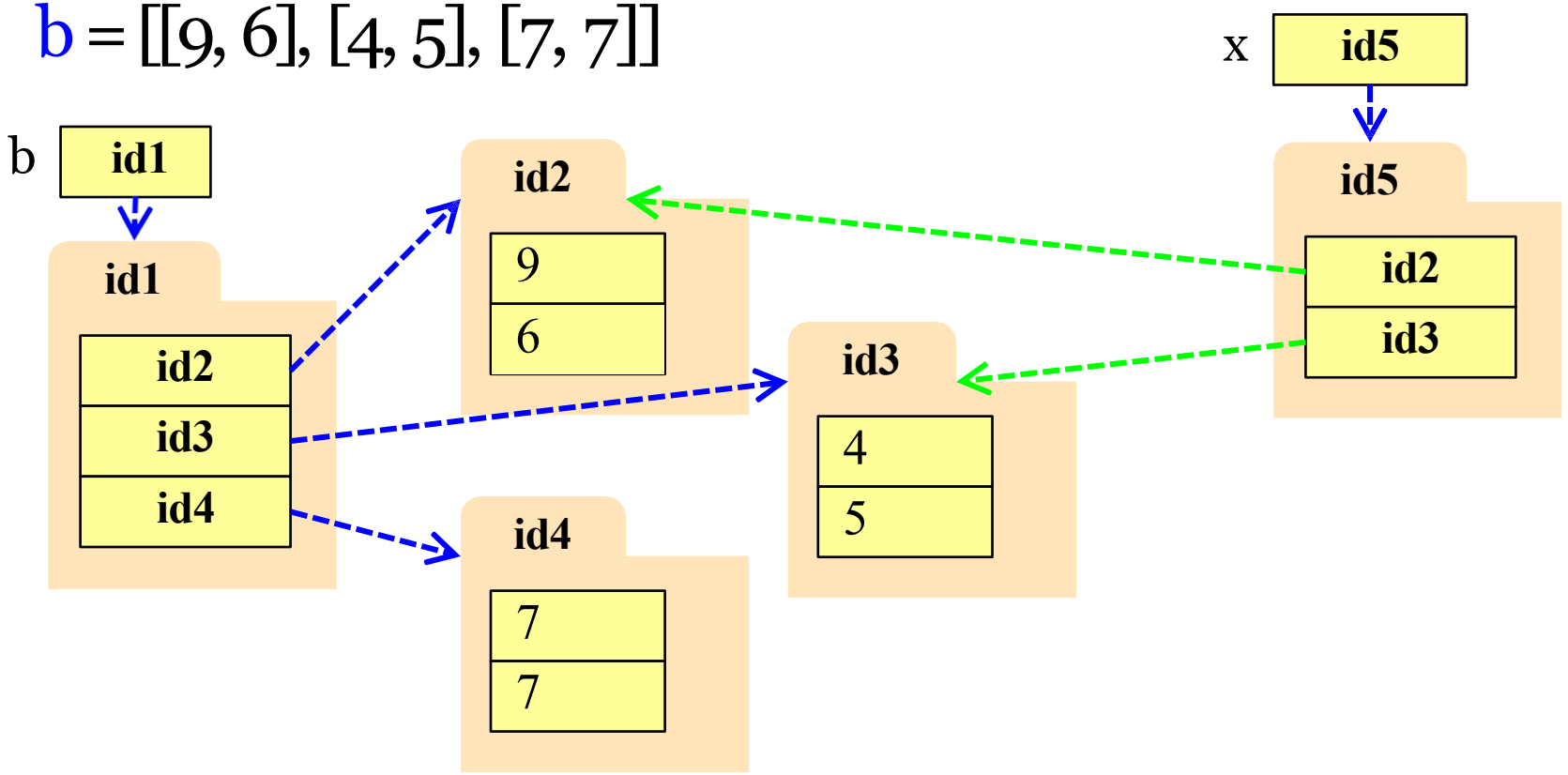

Slices and Multidimensional Lists

- Create a nested list

  >>> b = [[9,6],[4,5],[7,7]]
- Get a slice

  >>> x = b[:2]
- Append to a row of x

  >>> x[1].append(10)
- x now has nested list

  [[9, 6], [4, 5, 10]]

- What are the contents of the list (with name) b?

A: [[9,6],[4,5],[7,7]]
B: [[9,6],[4,5,10]]
C: [[9,6],[4,5,10],[7,7]]
D: [[9,6],[4,10],[7,7]]
E: I don't know

Slices and Multidimensional Lists

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  [[9, 6], [4, 5, 10]]

- What are the contents of the list (with name) in b?

A: [[9,6],[4,5],[7,7]]
B: [[9,6],[4,5,10]]
C: [[9,6],[4,5,10],[7,7]]
D: [[9,6],[4,10],[7,7]]
E: I don't know

Simple Example

```
def all_nums(table):
    """Returns True if table contains only numbers

    Precondition: table is a (non-ragged) 2d List"""
    result = True
    # Walk through table
    for row in table:
        # Walk through the row
        for item in row:
            if not type(item) in [int,float]:
                result = False

    return result
```

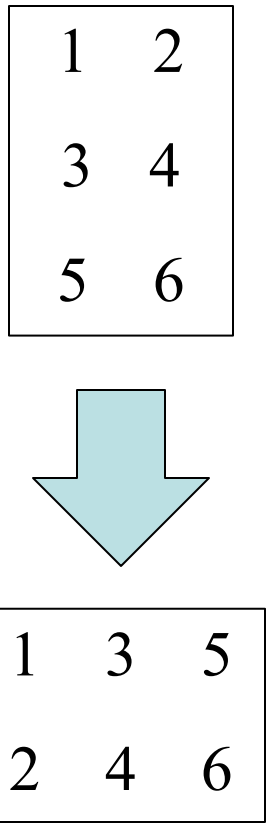
Accumulator

First Loop

Second Loop

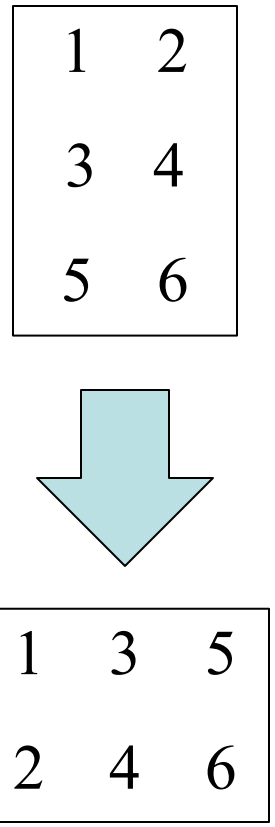
Transpose: A Trickier Example

```
def transpose(table):
    """Returns: copy of table with rows and columns swapped
    Precondition: table is a (non-ragged) 2d List"""


    result = []                 # Result (new table) accumulator
    # Loop over columns
        # Add each column as a ROW to result


    return result
```



Transpose: A Trickier Example

```
def transpose(table):
    """Returns: copy of table with rows and columns swapped
    Precondition: table is a (non-ragged) 2d List"""
    numrows = len(table)   # Need number of rows
    numcols = len(table[0]) # All rows have same no. cols
    result = []                    # Result (new table) accumulator
    for m in range(numcols):
        # Get the column elements at position m
        # Make a new list for this column
        # Add this row to accumulator table

    return result
```



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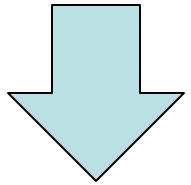
    numcols = len(table[0]) # All rows have same no. cols
    result = []                  # Result (new table) accumulator
    for m in range(numcols):
        row = []                 # Single row accumulator
        for n in range(numrows):
            row.append(table[n][m]) # Create a new row list
        result.append(row)       # Add result to table
    return result
```

1	2
3	4
5	6



1	3	5
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    result = []                                  ) accumulator
    for m in range(numc
        row = []                                 accumulator
        for n in range(numrows):
            row.append(table[n][m]) # Create a new row list
        result.append(row)       # Add result to table
    return result
```
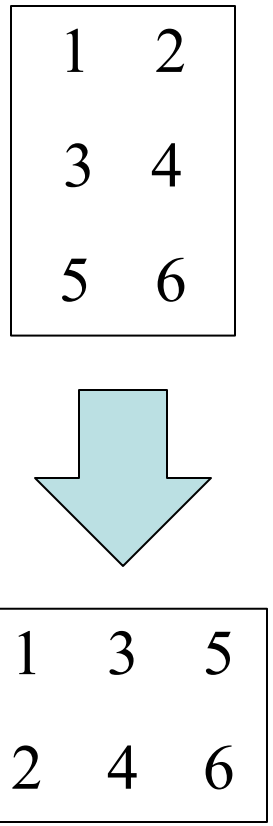
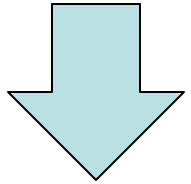

Accumulator for each loop



A Mutable Example

```
def add_ones(table):
    """Adds one to every number in the table
    Preconditions: table is a 2d List,
    all table elements are int"""
    # Walk through table

        # Walk through each column

            # Add 1 to each element

    # No return statement
```

1	3	5
2	4	6



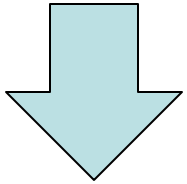
2	4	6
3	5	7

A Mutable Example

```
def add_ones(table):
    """Adds one to every number in the table
    Preconditions: table is a 2d List,
    all table elements are int"""
    # Walk through table
    for rpos in range(len(table)):
        # Walk through each column
        for cpos in range(len(table[rpos])):
            table[rpos][cpos] = table[rpos][cpos]+1

    # No return statement
```

Do not loop over the table

1	3	5
2	4	6



2	4	6
3	5	7

Key-Value Pairs

- The last built-in type: dictionary (or dict)
  - One of the most important in all of Python
  - Like a list, but built of key-value pairs
- **Keys:** Unique identifiers
  - Think social insurance number
  - At CC we have student id: 138283
- **Values:** Non-unique Python values (same values possible)
  - John Smith
  - John Smith

Idea: Lookup values by keys

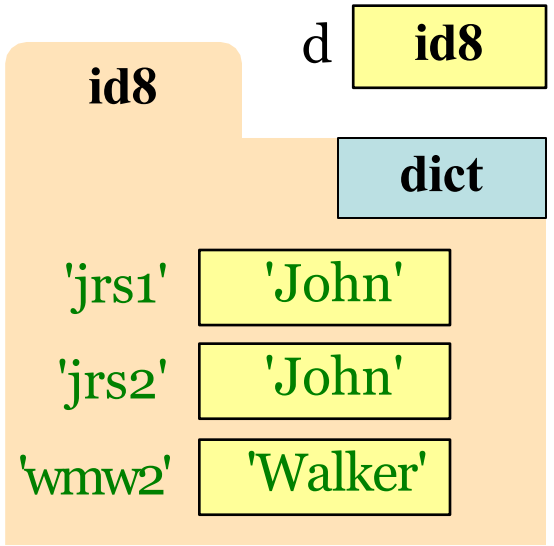
Basic Syntax

- Create with format: {k1:v1, k2:v2, …}
  - Both keys and values must exist
  - **Ex:** d={'jrs1':'John','jrs2':'John','wmw2':'Walker'}
- **Keys** must be **non-mutable**
  - ints, floats, bools, strings, tuples
  - **Not** lists or custom objects
  - Changing a key's contents hurts lookup
- **Values** can be **anything**

Using Dictionaries (Type dict)

- Access elts. like a list
  - d['jrs1'] evals to 'John'
  - d['jrs2'] does too
  - d['wmw2'] evals to 'Walker'
  - d['abc1'] is an **error**
- Can test if a key exists
  - 'jrs1' in d evals to True
  - 'abc1' in d evals to False
- But cannot slice ranges!

d = {'jrs1':'John','jrs2':'John', 'wmw2':'Walker'}

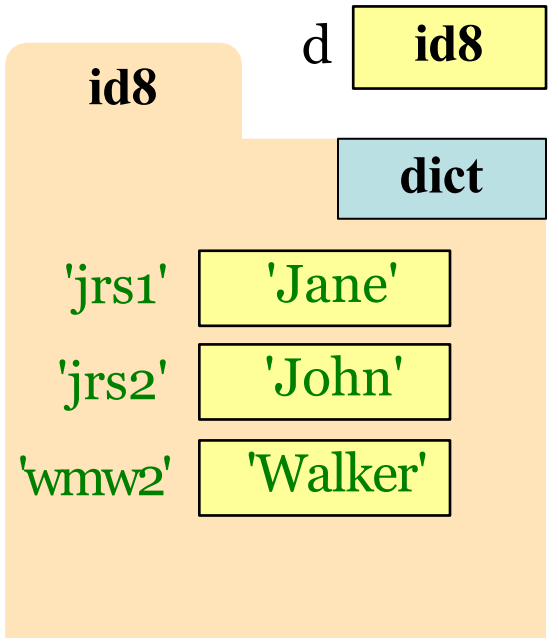


Key-Value order in folder is not important

Dictionaries Can be Modified

- **Can reassign values**
  - d['jrs1'] = 'Jane'
  - Very similar to lists
- Can add new keys
  - d['aaa1'] = 'Allen'
  - Do not think of order
- Can delete keys
  - del d['wmw2']
  - Deletes both key, value

```
d = {'jrs1':'John','jrs2':'John',
     'wmw2':'Walker'}
```



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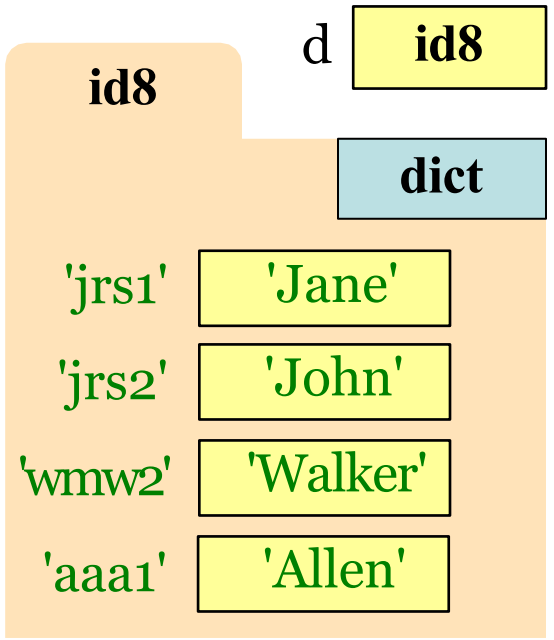

Nesting Dictionaries

- Remember, values can be anything
  - Only restrictions are on the keys
- Values can be lists (**Visualizer**)
  - d = {'a':[1,2], 'b':[3,4]}
- Values can be other dicts (**Visualizer**)
  - d = {'a':{'c':1,'d':2}, 'b':{'e':3,'f':4}}
- Access rules similar to nested lists
  - **Example:** d['a']['d'] = 10

Dictionaries: Iterable, but not Sliceable

- Can loop over a dict
  - Only gives you the keys
  - Use key to access value

```
for k in d:
    # Loops over keys
    print(k)     # key
    print(d[k])  # value
```

- Can iterate over values
  - **Method:** d.values()
  - But no way to get key
  - Values are not unique

```
# To loop over values only
for v in d.values():
    print(v)     # value
```

Other Iterator Methods

- **Keys:** d.keys()
  - Sames a normal loop
  - Good for *extraction*
  - keys = list(d.keys())

```
for k in d.keys():
    # Loops over keys
    print(k)     # key
    print(d[k])  # value
```

- **Items:** d.items()
  - Gives key-value pairs
  - Elements are tuples
  - Specialized uses

```
for pair in d.items():
    print(pair[0]) # key
    print(pair[1]) # value
```

Other Iterator Methods

- **Keys:** d.keys()
  - Sames a normal loop
  - Good for *extraction*
  - keys
- **Items:** d.items()
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```
for k in d.keys():
    # Loops over keys
    print(k)     # key
    print(d[k]) # value
```

So mostly like loops over lists

```
for pair in d.items():
    print(pair[0]) # key
    print(pair[1]) # value
```

Dictionary Loop with Accumulator

```
def max_grade(grades):
    """Returns max grade in the grade dictionary

    Precondition: grades has netids as keys, ints as values"""
    maximum = 0                    # Accumulator
    # Loop over keys
    for k in grades:
        if grades[k] > maximum:
            maximum = grades[k]


    return maximum
```

Mutable Dictionary Loops

- Restrictions are different than list
  - Okay to loop over dictionary being changed
  - You are looping over *keys*, not *values*
  - Like looping over positions
- But you **may not add or remove** keys!
  - Any attempt to do this will fail
  - Have to create a key list if you want to do